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Chu et al.

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(54) **LIGHT-EMITTING DEVICE AND DISPLAY PANEL INCLUDING THE SAME**

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(58) **Field of Classification Search**
None
See application file for complete search history.

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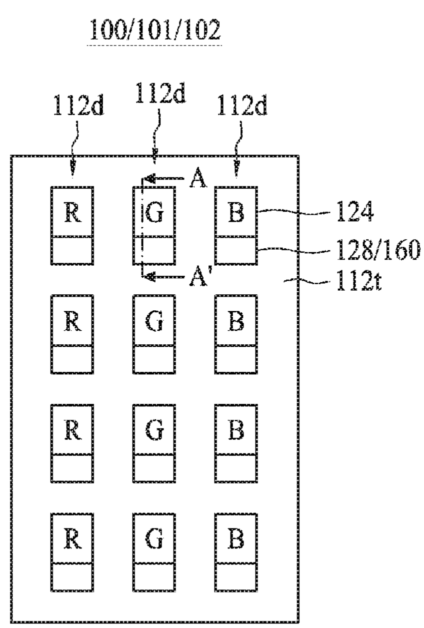
(57) **ABSTRACT**

A light-emitting device includes an organic light-emitting layer, a first electrode disposed at one side of the organic light-emitting layer, and a second electrode disposed at the same side of the organic light-emitting layer as the first electrode. The first electrode is spaced apart from the second electrode. A display panel includes a substrate including a display region and a touch sensing region defined along a substrate-horizontal direction, at least one light-emitting device disposed over the substrate in the display region, and at least one touch sensor disposed over the substrate in the touch sensing region. The display region and the touch sensing region are not overlapped.

20 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

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G06F 3/041	(2006.01)
H01L 27/32	(2006.01)
G06F 3/044	(2006.01)

(52) **U.S. Cl.**

CPC ***H01L 27/323*** (2013.01); ***H01L 27/3227*** (2013.01); ***H01L 27/3262*** (2013.01); ***H01L 51/5225*** (2013.01); ***H01L 51/56*** (2013.01); *H01L 27/3211* (2013.01)

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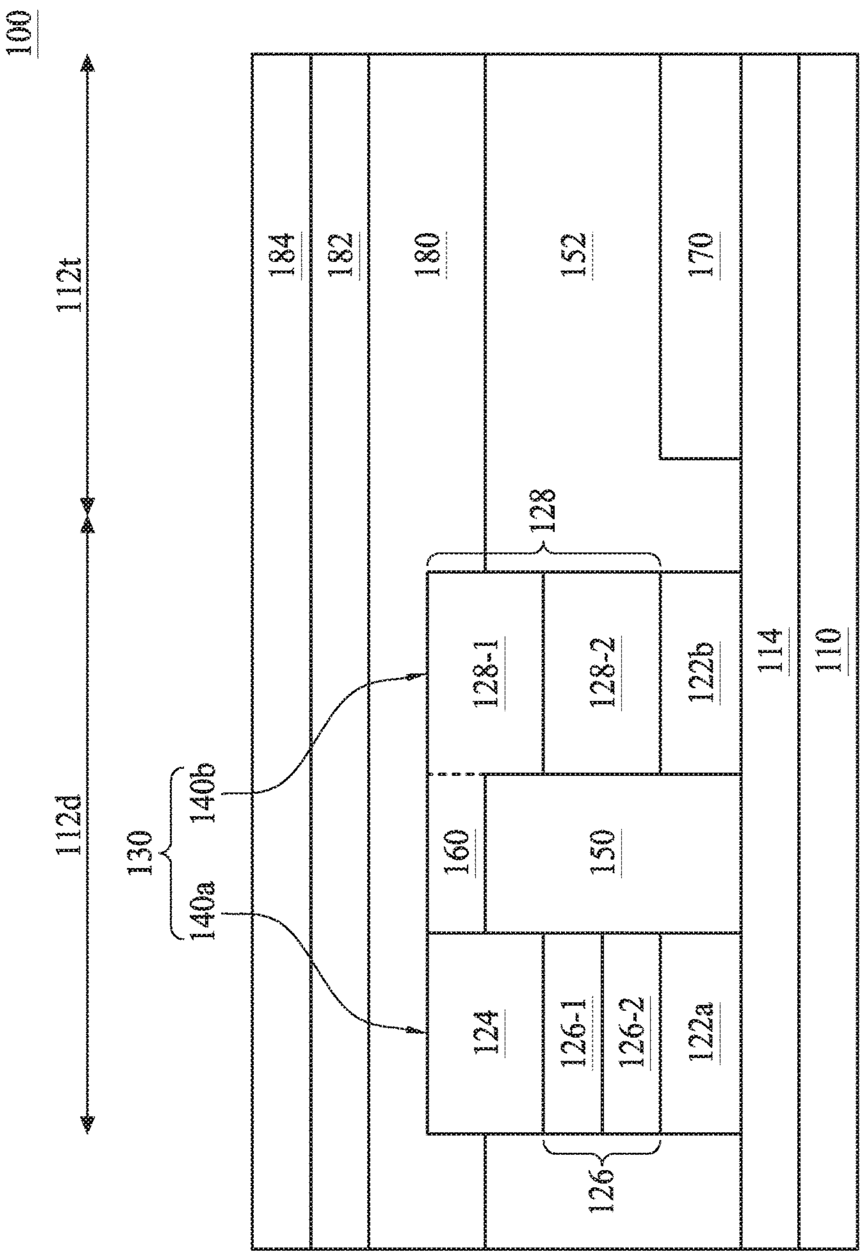
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126-2
122a
126

FIG. 2

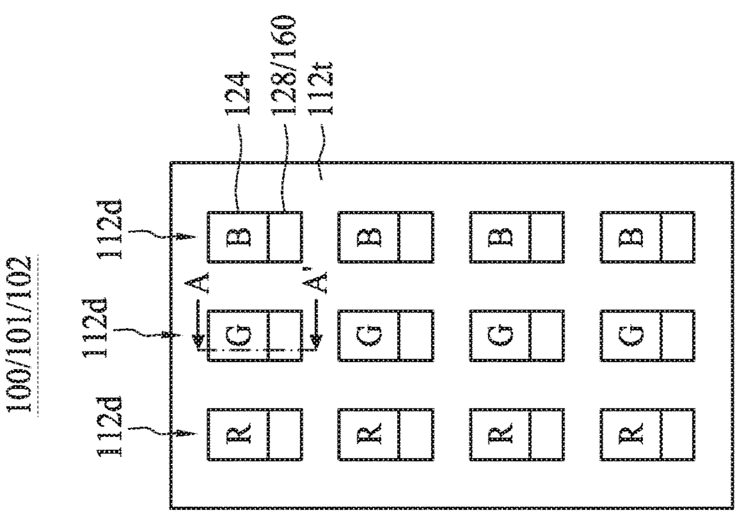
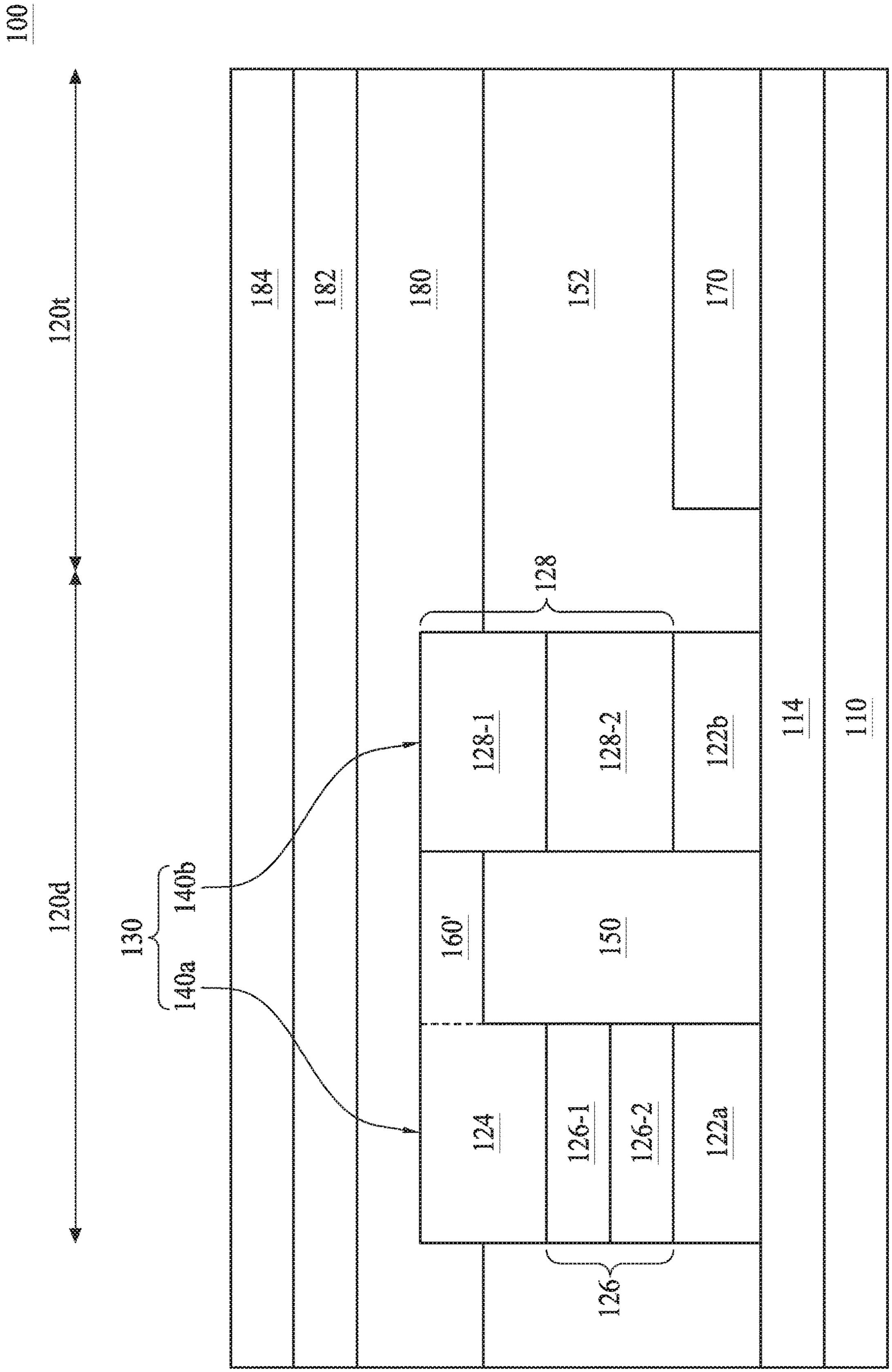

100/101/102
112d
112d
112d
124
128/160
112t
A
A'
B
B
B
B
G
G
G
G
R
R
R
R

FIG. 1



100
120t
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130
140a
140b
184
182
180
152
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128
128-1
128-2
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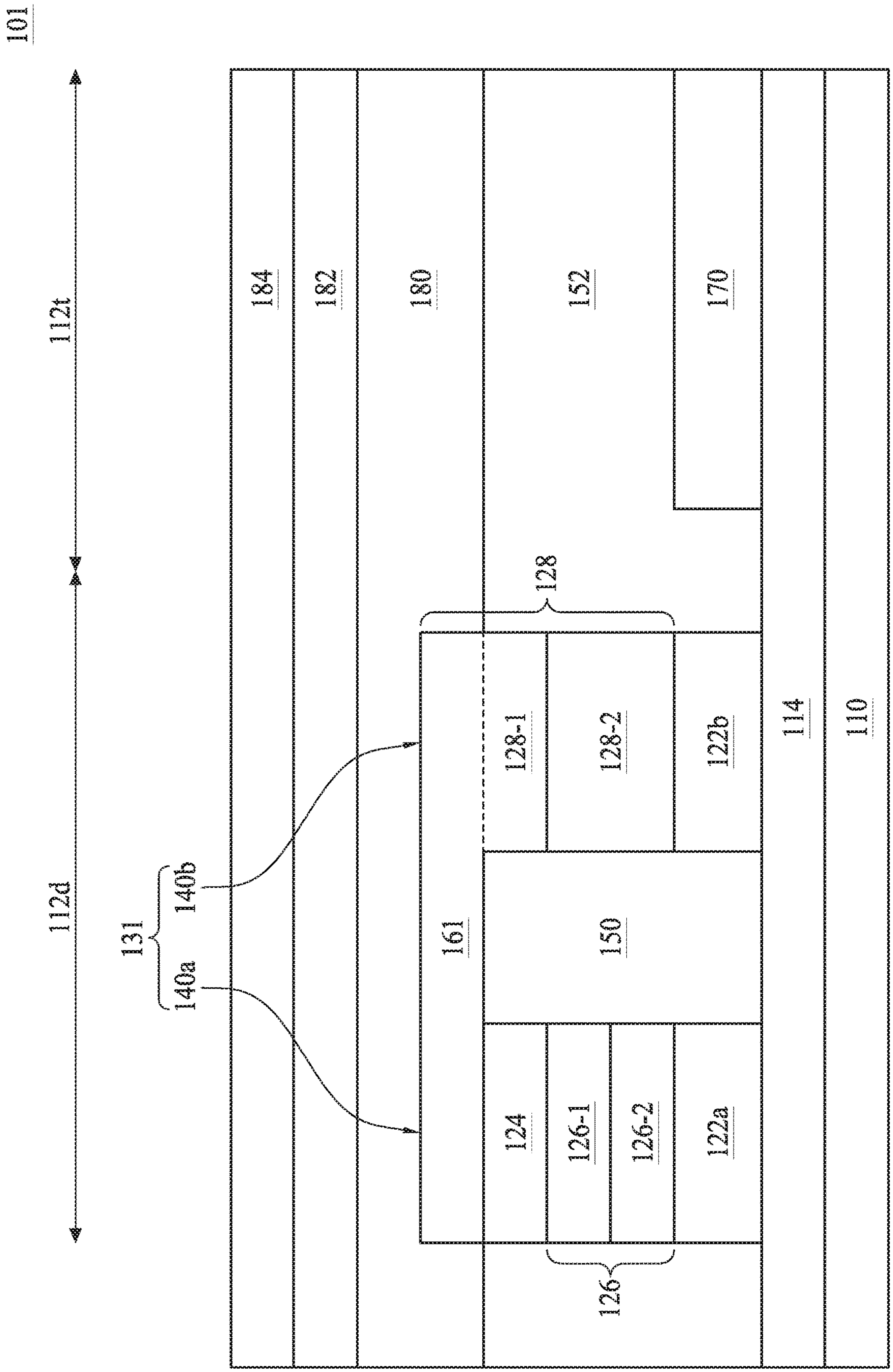
114
110
160'
150
124
126-1
126-2
122a
126

FIG. 3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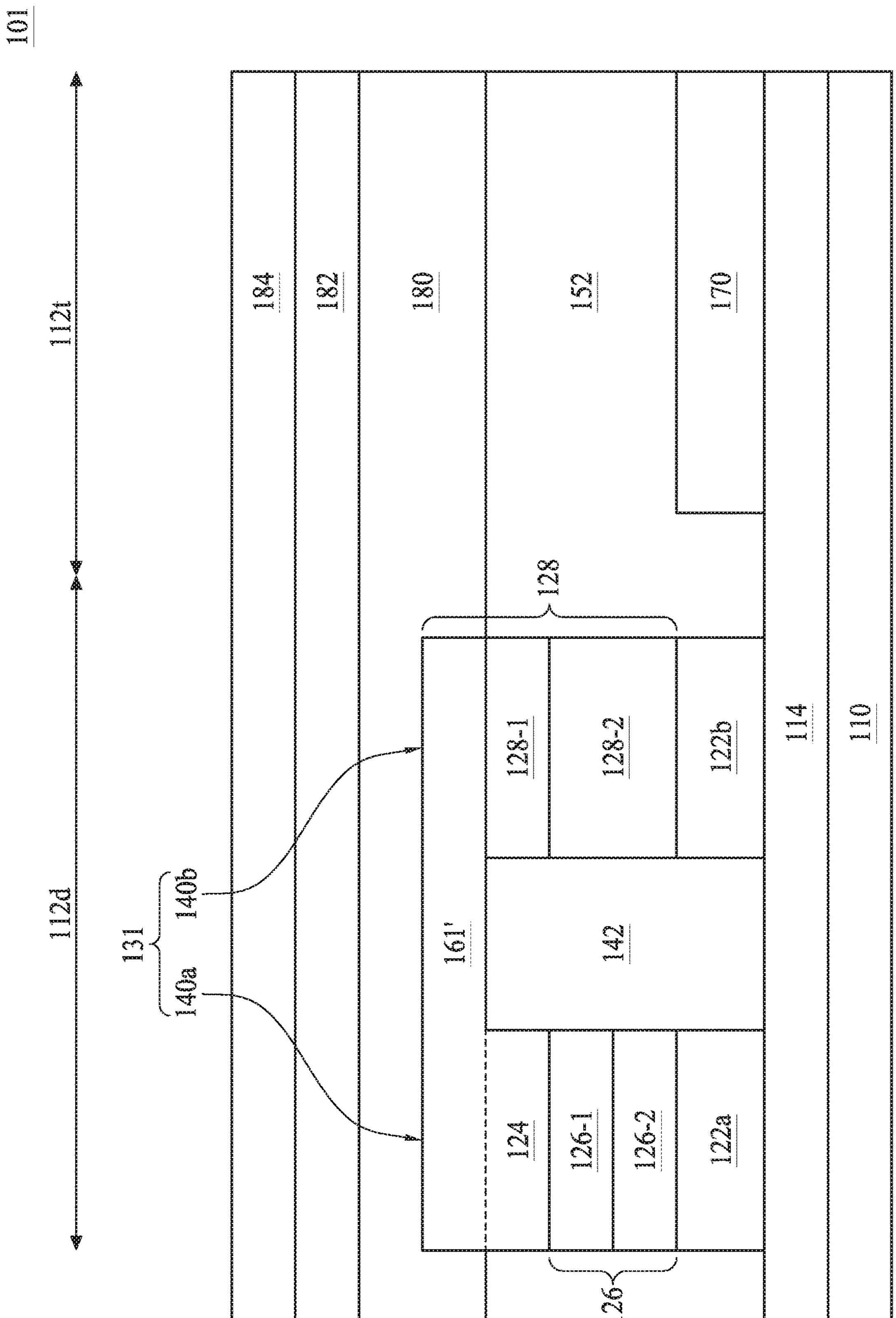
126-1
126-2
122a
126

FIG. 4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110
161'
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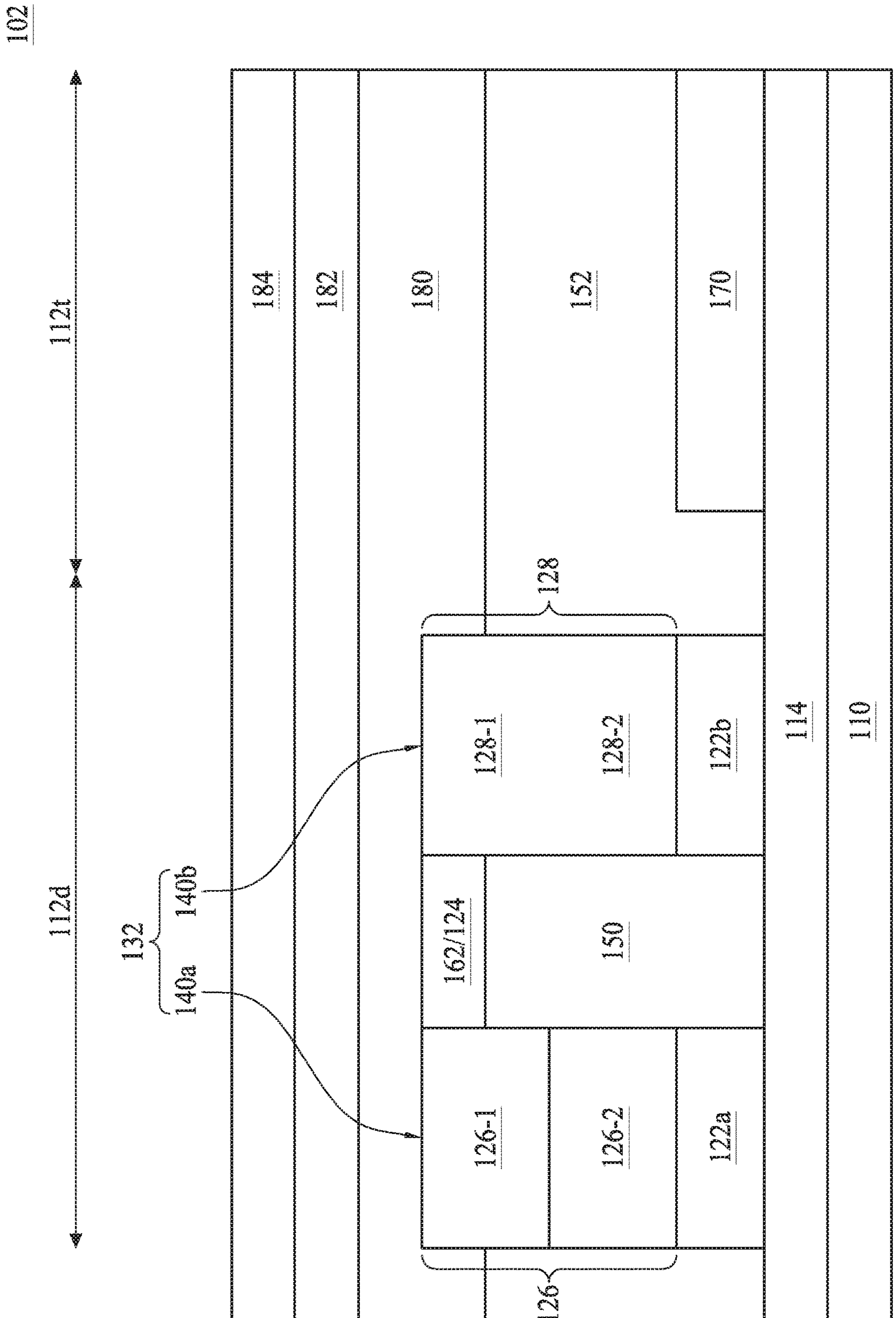
124
126-1
126-2
122a
126

FIG. 5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140b
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162/124
150
126-1
126-2
122a
126

FIG. 6

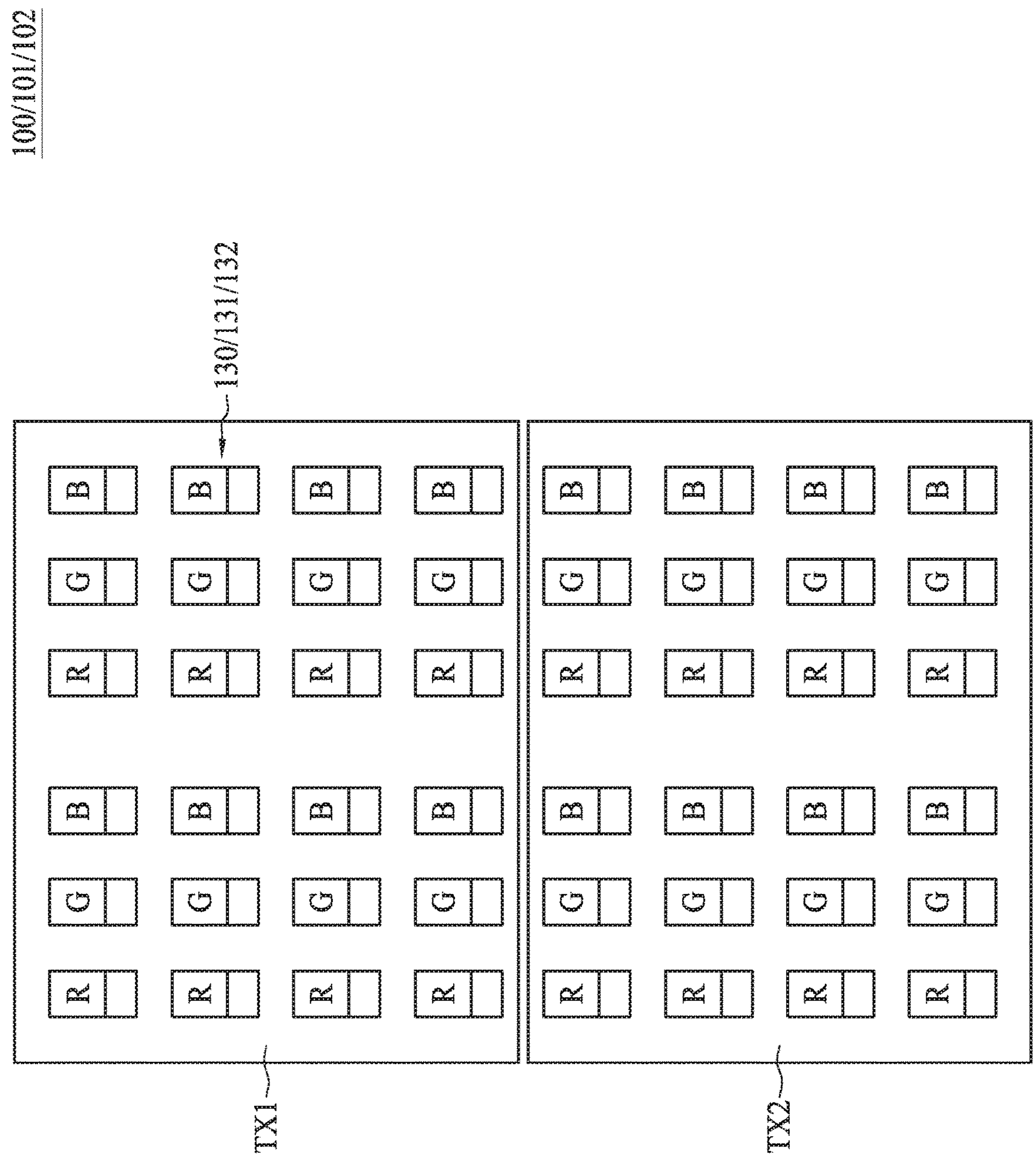

FIG. 7

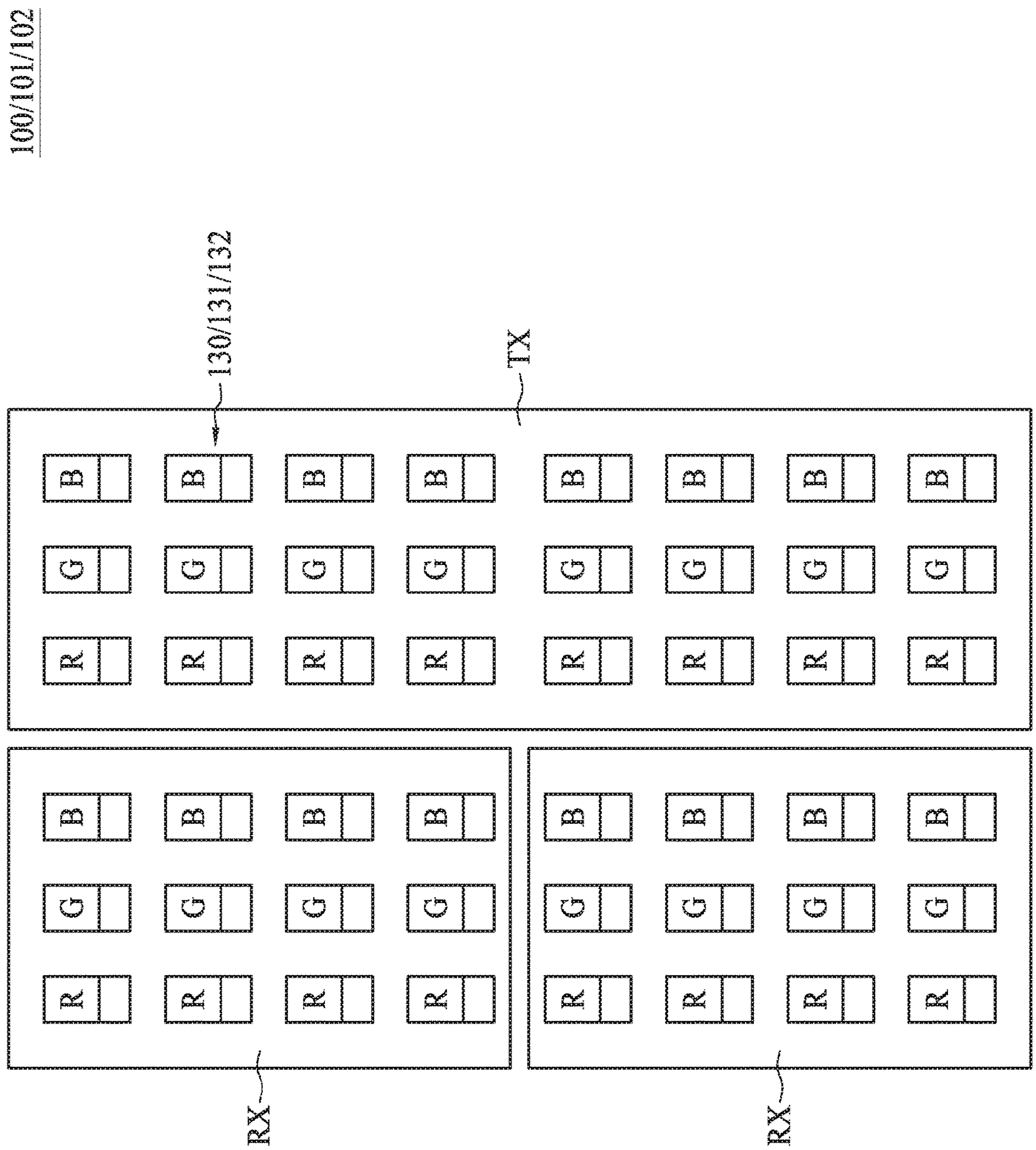

FIG. 8

LIGHT-EMITTING DEVICE AND DISPLAY PANEL INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority of U.S. Provisional Patent Application Ser. No. 62/487,097, filed on Apr. 19, 2017, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure is related to a light-emitting device and a display panel including the same, especially to an organic light-emitting device and a touch display panel including the same.

BACKGROUND

In current information era, human beings by degrees tend to rely on electronic products. The electronic products such as mobile phones, handheld personal computers (PCs), personal digital assistants (PDAs) and smart phones have pervaded everywhere in our daily life. To meet current demands on portable, compact, and user-friendly information technology (IT) products, touch panels have been introduced as input devices in replacement of conventional keyboards or mice.

A touch panel (or a touch screen) is widely used in electronic devices to detect an input action or an event by a user. Typically, the touch panel may detect the presence and location of a touch of the user by generating an electrical signal when the touch panel is touched by a finger, a stylus pen, or the like. The touch panel is usually mounted on a display panel, e.g., an organic light-emitting diode (OLED) display panel, a liquid crystal display (LCD) panel, etc., or may be formed within the display panel. The touch panel may be classified into, e.g., a resistive touch panel, a capacitive touch panel, an electromagnetic touch panel, an infrared touch panel, a surface acoustic wave (SAW) touch panel, a near field imaging (NFI) touch panel, etc. Among the touch panels, a touch display panel capable of performing both a touch function and a display function is one of the most popular products at present.

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a plan view of a touch display panel according to aspects of the present disclosure in some embodiments.

FIG. **2** is a schematic drawing illustrating a light-emitting device and a portion of the touch display panel according to aspects of the present disclosure in some embodiments.

FIG. **3** is a schematic drawing illustrating a light-emitting device according to aspects of the present disclosure in some embodiments.

FIG. **4** is a schematic drawing illustrating a light-emitting device according to aspects of the present disclosure in some embodiments.

FIG. **5** is a schematic drawing illustrating a light-emitting device according to aspects of the present disclosure in some embodiments.

FIG. **6** is a schematic drawing illustrating a light-emitting device according to aspects of the present disclosure in some embodiments.

FIG. **7** is a plan view of a touch display panel according to aspects of the present disclosure in some embodiments.

FIG. **8** is a plan view of a touch display panel according to aspects of the present disclosure in some embodiments.

DETAILED DESCRIPTION

The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of elements and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

Further, spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper”, “on” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. The apparatus may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may likewise be interpreted accordingly.

As used herein, the terms such as “first”, “second” and “third” describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another. The terms such as “first”, “second” and “third” when used herein do not imply a sequence or order unless clearly indicated by the context.

FIG. **1** is a plan view of a touch display panel according to aspects of the present disclosure in some embodiments, FIG. **2** is a schematic drawing illustrating a light-emitting device and a portion of the touch display panel according to aspects of the present disclosure in some embodiments. Additionally, the light-emitting device shown in FIG. **2** can be a cross-sectional view taken along line A-A' of FIG. **1** in some embodiments. Referring to FIG. **1**, a display panel is provided. In some embodiments, the display panel can be a touch display panel **100**. The touch display panel **100** includes a substrate **110**. In some embodiments of the present disclosure, the substrate **110** can include one of the following materials: polyethylene naphthalate (PEN), polyethylene terephthalate (PET), polycarbonate (PC), and polyimide (PI), but the disclosure is not limited thereto. In some embodiments, at least one display region **112*d*** and at least one touch sensing region **112*t*** are defined along a substrate-horizontal direction as shown in FIGS. **1** and **2**. In other words, the display region **112***d* and the touch sensing region **112***t* are not overlapped. In some embodiments, the touch sensing regions **112***t* surround the display region **112***d* as shown in FIG. **1**, but the disclosure is not limited thereto.

The display regions **112***d* are defined to accommodate sub-pixels. It should be noted that the term "sub-pixel" is employed in its art recognized usage to designate a unit that can be stimulated to emit light independently. The sub-pixel is generally used to designate the smallest addressable unit in a display panel that can be independently addressable to emit light of a specific color. Usually, the term "subpixel" is used in multicolor display panels and is employed to designate any portion of a pixel. For example, a blue sub-pixel is that portion of a pixel, which can be addressed to produce blue light. Accordingly, the display region **112***d* is defined to accommodate a first sub-pixel R addressed to produce red light, another display region **112***d* is defined to accommodate a second sub-pixel G addressed to produce a green light, and still another display region **112***d* is defined to accommodate a third sub-pixel B addressed to produce a blue light. In some embodiments, the first sub-pixel R, the second sub-pixel G and the third sub-pixel B are periodically arranged in a row direction, but the disclosure is not limited thereto. In some embodiments, the same sub-pixels R, G, or B are repeatedly arranged in a column direction, but the disclosure is not limited thereto. As shown in FIG. **1**, the display regions **112***d* for accommodating the different sub-pixels R, G and B include a same size. However, in some embodiments of the disclosure, the display regions **112***d* for accommodating the different sub-pixels R, G and B can include different sizes.

Still referring to FIG. **1**, the touch display panel **100** includes an array layer **114** disposed over the substrate **110**. The abovementioned sub-pixels R, G and B are independently controlled by, for example, thin film transistors (TFTs). The TFTs are arranged in an array and thus structure including the TFT array is herein referred to as the array layer **114**. In some embodiments, such TFTs can be constructed by using amorphous silicon, low temperature polycrystalline silicon, single crystalline silicon, other inorganic semiconductors, organic semiconductor materials, or the like.

Referring to FIG. **1**, the touch display panel **100** includes at least one light-emitting device **130** disposed over the substrate **102** in each of the display regions **112***d*. For example, a light-emitting device **130** emitting red light is disposed in the display regions **112***d* for the red sub-pixels R, a light-emitting device **130** emitting green light is disposed in the display regions **112***d* for the green sub-pixels G, and a light-emitting device **130** emitting blue light is disposed in the display regions **112***d* for the blue sub-pixels B. In some embodiments of the present disclosure, the light-emitting device **130** includes a first electrode **122***a*, a second electrode **122***b*, and a light-emitting layer **124**. More importantly, the first electrode **122***a* is disposed at one side of the light-emitting layer **124**, and the second electrode **122***a* is disposed at the same side of the light-emitting layer **124** as the first electrode **122***a*. In other words, both of the first electrode **122***a* and the second electrode **122***b* are disposed at the same side of the light-emitting layer **124** as shown in FIG. **2**. And the first electrode **122***a* is spaced apart and electrically isolated from the second electrode **122***b*. Methods for preparing such light-emitting device **130** are well known in the art. For example, a conductive layer (not shown) is formed over the substrate **102** and patterned to form the first electrode **122***a* and the second electrode **122***b* simultaneously in each of the display regions **112***d*. Usually, metals such as magnesium (Mg), magnesium-silver alloy, aluminum (Al), lithium aluminum alloy and calcium (Ca) have been generally used to form the first electrode **122***a* and the second electrode **122***b*, but the disclosure is not limited thereto. In some embodiments, the light-emitting layer **124** includes an organic light-emitting layer. Accordingly, the light-emitting device **130** is an organic light-emitting device.

When a voltage is applied across the first electrode **122***a* and the second electrode **122***b*, electrons are injected from the cathode into the organic light-emitting layer **124** and holes are injected from the anode into the organic light-emitting layer **124**. The holes and electrons recombine in the organic light-emitting layer **124**, which emits light. To achieve efficient electroluminescence, some known organic light emitting devices include multiple layers. In some embodiments, a first carrier layer **126** is disposed over the first electrode **122***a* while a second carrier layer **128** is disposed over the second electrode **122***b*. And the first carrier layer **126** is spaced apart and electrically isolated from the second carrier layer **128**. In some embodiments, the first electrode **122***a* contacts the first carrier layer **126**, and the second electrode **122***b* contacts the second carrier layer **128**. As shown in FIG. **2**, the first carrier layer **126** is coupled to the light-emitting layer **124** and the first electrode **122***a*, and the second carrier layer **128** is coupled to the light-emitting layer **124** and the second electrode **122***b*. In some embodiments, the first electrode **122***a* is an anode and the second electrode **122***b* is a cathode. The first carrier layer **126** can include a hole-transporting layer (HTL) **126-1** and a hole-injecting layer (HIL) **126-2** The hole-transporting layer **126-1** and the hole-injecting layer **126-2** include organic materials, and thus the first carrier layer **126** is referred to as a first organic layer **126**, but the disclosure is not limited thereto. The second carrier layer **128** can include an electron-transporting layer (ETL) **128-1** and an electron-injecting layer (EIL) **128-2**. The electron-transporting layer **128-1** and the electron-injecting layer **128-2** include organic materials, and thus the second carrier layer **128** is referred to as a second organic layer **128**, but the disclosure is not limited thereto.

Still referring to FIG. **2**, the light-emitting device **130** can be referred to include a first structure **140***a* and a second structure **140***b* spaced apart from each other. In some embodiments, a dielectric structure **150** can be disposed between the first structure **140***a* and the second structure **140***b*, but the disclosure is not limited thereto. The dielectric structure **150** spaces apart the first structure **140***a* from the second structure **140***b*, as shown in FIG. **2**. The first structure **140***a* includes the first electrode **122***a*, the light-emitting layer **124** disposed over the first electrode **122***a*, and the first organic layer **126** sandwiched between the first electrode **122***a* and the light-emitting layer **124**. The second structure **140***b* includes the second electrode **122***b* and the second organic layer **128** disposed over the second electrode **122***b*. More importantly, the light-emitting device **130** includes a connecting bridge **160** or **160'** connecting the light-emitting layer **124** of the first structure **140***a* and the second organic layer **128** of the second structure **140***b*, as shown in FIG. **2**. In some embodiments, the connecting bridge **160** or **160'** is disposed over the dielectric structure **150** to connect the light-emitting layer **124** and the electron-transporting layer **128-1** of the second structure **140***b*. As shown in FIGS. **2** and **3**, the connecting bridge **160** or **160'** contacts a portion of the first structure **140***a* and a portion of the second structure **140***b*. For example but not limited to, the connecting bridge **160** or **160'** contacts at least a portion of a sidewall of the light-emitting layer **124** and at least a portion of a sidewall of the second organic layer **128**. In some embodiments, the connecting bridge **160** and the electron-transporting layer **128-1** include the same material, as shown in FIG. **2**. Accordingly, electrons from the second electrode **122***b* pass the connecting bridge **160** and recombine with the hole from the first electrode **122***a* in the light-emitting layer **124**, where lights are emitted. In some embodiments, the connecting bridge **160'** and the light-emitting layer **124** include the same material, as shown in FIG. **3**. Accordingly, electrons from the second electrode **122***b* recombine with the hole from the first electrode **122***a* in both of the connecting bridge **160'** and the light-emitting layer **124**, where lights are emitted.

Referring to FIG. **4**, which is a schematic drawing illustrating a light-emitting device and a portion of the display panel according to aspects of the present disclosure in some embodiments. In some embodiments, a display panel such as a touch display panel **101** is provided as shown in FIG. **4**. Additionally, the touch display panel **101** shown in FIG. **4** can also be a cross-sectional view taken along line A-A' of FIG. **1**. The touch display panel **101** can be similar to the touch display panel **100**, and thus only the difference is detailed. Referring to FIG. **4**, the display panel **101** includes a light-emitting device **131** disposed over the substrate **110** in each of the display regions **112***d*. The light-emitting device **131** includes a first electrode **122***a*, a second electrode **122***b*, and a light-emitting layer **124**. In some embodiments, the light-emitting layer **124** is an organic light-emitting layer, but the disclosure is not limited to this. As mentioned above, both of the first electrode **122***a* and the second electrode **122***b* are disposed at the same side of the light-emitting layer **124**. And first electrode **122***a* is electrically isolated from the second electrode **122***b*.

In some embodiments, a first carrier layer **126** is disposed over the first electrode **122***a* while a second carrier layer **128** is disposed over the second electrode **122***b*. The first carrier layer **126** contacts the first electrode **122***a*, and the second carrier layer **128** contacts the second electrode **122***b*. And the first carrier layer **126** is spaced apart from the second carrier layer **128**. As shown in FIG. **4**, the first carrier layer **126** is coupled to the light-emitting layer **124** and the first electrode **122***a*, and the second carrier layer **128** is coupled to the light-emitting layer **124** and the second electrode **122***b*. As shown in FIGS. **4** and **5**, both of the first layer carrier **126** and the second carrier layer **128** are disposed at the same side of the light-emitting layer **124**. Furthermore, the first carrier layer **126** and the second carrier layer **128** are disposed at the same side of the organic light-emitting layer **124** as the first electrode **122***a* and the second electrode **122***b*. In some embodiments, the first electrode **122***a* is an anode and the second electrode **122***b* is a cathode. The first carrier layer **126** can include a hole-transporting layer **126-1** and a hole-injecting layer **126-2**. The hole-transporting layer **126-1** and the hole-injecting layer **126-2** include organic materials, and thus the first carrier layer **126** is referred to as a first organic layer **126**, but the disclosure is not limited thereto. The second carrier layer **128** can include an electron-transporting layer **128-1** and an electron-injecting layer **128-2**. The electron-transporting layer **128-1** and the electron-injecting layer **128-2** include organic materials, and thus the second carrier layer **128** is referred to as a second organic layer **128**, but the disclosure is not limited thereto.

Still referring to FIG. **4**, the light-emitting device **131** can be referred to include a first structure **140***a* and a second structure **140***b* spaced apart from each other. In some embodiments, a dielectric structure **150** can be disposed between the first structure **140***a* and the second structure **140***b*, but the disclosure is not limited thereto. The dielectric structure **150** spaces apart and electrically isolates the first structure **140***a* from the second structure **140***b*, as shown in FIG. **4**. The first structure **140***a* includes the first electrode **122***a*, the light-emitting layer **124** disposed over the first electrode **122***a*, and the first organic layer **126** sandwiched between the first electrode **122***a* and the light-emitting layer **124**. The second structure **140***b* includes the second electrode **122***b* and the second organic layer **128** disposed over the second electrode **122***b*. More importantly, the light-emitting device **131** includes a connecting bridge **161** or **161'** connecting the light-emitting layer **124** of the first structure **140***a* and the second organic layer **128** of the second structure **140***b*, as shown in FIGS. **4** and **5**. In some embodiments, the connecting bridge **161** or **161'** is disposed over the first structure **140***a*, the dielectric structure **150** and the second structure **140***b* to connect the light-emitting layer **124** and the electron-transporting layer **128-1** of the second structure **140***b*. As shown in FIG. **4**, the connecting bridge **161** or **161'** contacts a portion of the first structure **140***a* and a portion of the second structure **140***b*. For example but not limited to, the connecting bridge **161** or **161'** contacts at least a top surface of the light-emitting layer **124** and at least a top surface of the second organic layer **128**. In some embodiments, the connecting bridge **161** and the electron-transporting layer **128-1** include the same material, as shown in FIG. **4**. Accordingly, electrons from the second electrode **122***b* pass the connecting bridge **161** and recombine with the hole from the first electrode **122***a* in the light-emitting layer **124**, where lights are emitted. In some embodiments, the connecting bridge **161'** and the light-emitting layer **124** include the same material, as shown in FIG. **5**. Accordingly, electrons from the second electrode **122***b* recombine with the hole from the first electrode **122***a* in both of the connecting bridge **161'** and the light-emitting layer **124**, where lights are emitted.

Referring to FIG. **6**, which is a schematic drawing illustrating a light-emitting device and a portion of the display panel according to aspects of the present disclosure in some embodiments. In some embodiments, a display panel such as a touch display panel **102** is provided as shown in FIG. **6**. Additionally, the display panel **102** shown in FIG. **6** can also be a cross-sectional view taken along line A-A' of FIG. **1**. The display panel **102** can be similar to the touch display panel **100**, and thus only the difference is detailed. Referring to FIG. **6**, the touch display panel **102** includes a light-emitting device **132** disposed over the substrate **110** in each of the display regions **112***d*. The light-emitting device **132** includes a first electrode **122***a*, a second electrode **122***b*, and a light-emitting layer **124**. In some embodiment, the light-emitting layer **124** is an organic light-emitting layer. As mentioned above, both of the first electrode **122***a* and the second electrode **122***b* are disposed at the same side of the light-emitting layer **124**. And first electrode **122***a* is electrically isolated from the second electrode **122***b*.

In some embodiments, a first carrier layer **126** is disposed over the first electrode **122***a* while a second carrier layer **128** is disposed over the second electrode **122***b*. The first carrier layer **126** contacts the first electrode **122***a* and the second carrier layer **128** contacts the second electrode **122***b*. And the first carrier layer **126** is spaced apart and electrically isolated from the second carrier layer **128**. As shown in FIG. **6**, the first carrier layer **126** is coupled to the first electrode **122***a*, and the second carrier layer **128** is coupled to the second electrode **122***b*. In some embodiments, the first electrode **122***a* is an anode and the second electrode **122***b* is a cathode. The first carrier layer **126** can include a hole-transporting layer **126-1** and a hole-injecting layer **126-2**. The hole-transporting layer **126-1** and the hole-injecting layer **126-2** include organic materials, and thus the first carrier layer **126** is referred to as a first organic layer **126**, but the disclosure is not limited thereto. The second carrier layer **128** can include an electron-transporting layer **128-1** and an electron-injecting layer **128-2**. The electron-transporting layer **128-1** and the electron-injecting layer **128-2** include organic materials, and thus the second carrier layer **128** is referred to as a second organic layer **128**, but the disclosure is not limited thereto. Accordingly, the holes from the first electrode **122***a* and the electrons from the second electrode **122***b* recombine in the organic light-emitting layer **124**, which is the connecting bridge **162**, where lights are emitted from.

Still referring to FIG. **6**, the light-emitting device **132** can be referred to include a first structure **140***a* and a second structure **140***b* spaced apart from each other. In some embodiments, a dielectric structure **150** can be disposed between the first structure **140***a* and the second structure **140***b*, but the disclosure is not limited thereto. The dielectric structure **150** spaces apart and electrically isolated the first structure **140***a* from the second structure **140***b*, as shown in FIG. **4**. The first structure **140***a* includes the first electrode **122***a* and the first organic layer **126** disposed over the first electrode **122***a*, and the second structure **140***b* includes the second electrode **122***b* and the second organic layer **128** disposed over the second electrode **122***b*. More importantly, the light-emitting device **132** includes a connecting bridge **162** connecting the first structure **140***a* and the second structure **140***b*, as shown in FIG. **6**. In some embodiments, the connecting bridge **162** is disposed over the dielectric structure **150**. As shown in FIG. **6**, the connecting bridge **162** contacts a portion of the first structure **140***a* and a portion of the second structure **140***b*. For example but not limited to, the connecting bridge **162** contacts at least a portion of sidewall of the first organic layer **126** and at least a portion of sidewall of the second organic layer **128**. In some embodiments, the connecting bridge **162** is the light-emitting layer **124**.

Referring to FIGS. **1-6**, the touch display panels **100**, **101** and **102** can further include at least one touch sensor **170** disposed over the substrate **110** in the touch sensing region **112***t*. As mentioned above, the touch sensing regions **112***t* can surround the display region **112***d* in some embodiments. Therefore, one or more touch sensors **170** can be disposed in the touch sensing regions **112***t* if required. In some embodiments, each sub-pixel includes one light-emitting device **130**, **131** or **132** and one touch sensor **170**. In some embodiments, each sub-pixel includes one light-emitting device **130**, **131** or **132** and a portion of one touch sensor **170**. In still some embodiments, each sub-pixel includes one light-emitting device **130**, **131** or **132** and a plurality of touch sensors **170**. It should be understood that the types and amounts of the touch sensor **170** can be modified according to different product requirements. In some embodiments, the touch sensor **170**, the first electrode **122***a* of the light-emitting device **130**, and the second electrode **122***b* of the light-emitting device **130** include the same material. In some embodiments, the touch sensor **170**, the first electrode **122***a*, and the second electrode **122***b* are made of the same conductive layer. For example but not limited to, a conductive layer is disposed over the substrate **110** and followed by patterning the conductive layer to form the touch sensor **170**, the first electrode **122***a* and the second electrode **122***b* in some embodiments.

Referring to FIGS. **2-6** again, the touch display panel **100**, **101** and **102** further includes a dielectric structure **152** disposed over the substrate **110** and the touch sensor **170**. At least a portion of the dielectric structure **152** is disposed between the touch sensor **170** and the light-emitting device **130**, **131** or **132** along the substrate-horizontal direction. Accordingly, the touch sensor **170** is electrically isolated from the light-emitting device **130**, **131** or **132** by the portion of the dielectric structure **152**. Accordingly, the display panels **100**, **101** and **102** are provided as an in-cell touch display panel.

Still referring to FIGS. **2-6**, the touch display panels **100**, **101** and **102** can further include a thin film encapsulation (TFE) layer **180** disposed over the substrate **112**. In some embodiments, the film encapsulation layer **180** is provided to encapsulate the light-emitting device **130**, **131** or **132**, the touch sensor **170** and the dielectric structure **152**, and thus to protect those elements and to provide a planar surface. Additionally, the touch display panels **100**, **101** and **102** selectively includes a polarizer **184** adhered to the thin film encapsulation layer **180** by an optical clear adhesive (OCA) **182**.

As mentioned above, one or more touch sensors **170** can be disposed in the touch sensing regions **112***t*. Referring to FIG. **7**, which is a plan view of a touch display panel according to aspects of the present disclosure in some embodiments, the touch sensors **170** include transmitter electrodes TX**1**, TX**2** . . . TXn in some embodiments. Accordingly, the touch sensors **170** are self-capacitance type touch sensors. When a finger touches the self-capacitance type touch sensor, capacitance change occurs. And a sensing circuit is able to sense a touch position and a touch area by measuring a change in capacitance (or electric charge) caused by an object contacting the self-capacitance type touch sensor to which a touch driving signal is applied.

Referring to FIG. **8**, which is a plan view of a touch display panel according to aspects of the present disclosure in some embodiments, the touch sensors **170** include transmitter electrodes TX and receive electrodes RX in some embodiments. Accordingly, the touch sensors **170** are mutual-capacitance type touch sensor uses mutual capacitance that occurs between the TX electrodes to which the touch driving signal is applied and the RX electrodes crossing the TX lines with a dielectric layer (or insulation layer) interposed between them. And a sensing circuit is able to sense a touch position and a touch area by receiving a change in the capacitance (or electric charge) of the touch sensor caused by an object contacting the touch sensor.

In the present disclosure, a polarizer is not necessary because the first electrode and the second electrode are disposed at the same side of the light-emitting layer. Therefore, light emission efficiency is improved and the display panel can be slimmer. Furthermore, since the touch sensing region and the display region are defined along the substrate-horizontal direction and are not overlapped each other, the light-emitting device disposed in the display region and the touch sensor disposed in the touch sensing region are not overlapped. Consequently, a slimmer touch display panel is provided by the present disclosure.

The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

What is claimed is:

1. A light-emitting device, comprising:
an organic light-emitting layer;
an anode disposed at one side of the organic light-emitting layer;
a first carrier layer, coupled to the organic light-emitting layer and the anode;
a cathode disposed at the same side of the organic light-emitting layer as the anode; and
a second carrier layer, coupled to the organic light-emitting layer and the cathode,
wherein the anode is spaced apart from the cathode, and the anode and the cathode are disposed on and in contact with a thin film transistor (TFT) array layer, and bottom surfaces of the anode and the cathode are coplanar with a top surface of the TFT array layer, and
wherein at least one of lateral sidewalls of the first carrier layer and the second carrier layer is in contact with the organic light-emitting layer from a cross section of the light-emitting device.

2. The light-emitting device of claim **1**, wherein the first carrier layer is spaced apart from the second carrier layer.

3. The light-emitting device of claim **1**, wherein the first carrier layer and the second carrier layer are disposed at the same side of the organic light-emitting layer as the anode and the cathode.

4. The light-emitting device of claim **1**, wherein the first carrier layer comprises a hole-transporting layer (HTL) and a hole-injecting layer (HIL), and the second carrier layer comprises an electron-transporting layer (ETL) and an electron-injecting layer (EIL).

5. A light-emitting device, comprising:
a first structure comprising:
an anode;
a light-emitting layer disposed over the anode; and
a first organic layer sandwiched between the anode and the light-emitting layer;
a second structure spaced apart from the first structure, the second structure comprising:
a cathode; and
a second organic layer disposed over the cathode, wherein a thickness of the first organic layer is different from a thickness of the second organic layer; and
a connecting bridge connecting the light-emitting layer of the first structure and the second organic layer of the second structure; and
an TFT array layer, wherein the first structure and the second structure are disposed on and in contact with the TFT array layer, and bottom surfaces of the anode and the cathode are coplanar with a top surface of the TFT array layer.

6. The light-emitting device of claim **5**, wherein the first organic layer comprises a hole-transporting layer (HTL) and a hole-injecting layer (HIL), and the second organic layer comprises an electron-transporting layer (ETL) and an electron-injecting layer (EIL).

7. The light-emitting device of claim **6**, wherein the connecting bridge and the electron-transporting layer comprise a same material.

8. The light-emitting device of claim **5**, wherein the connecting bridge and the light-emitting layer comprise a same material.

9. The light-emitting device of claim **5**, wherein the connecting bridge contacts at least a portion of the second organic layer and at least a portion of the light-emitting layer.

10. The light-emitting device of claim **5**, further comprising a dielectric structure spaces the first structure apart from the second structure.

11. A display panel, comprising:
a substrate comprising a plurality of display regions and a touch sensing region defined along a substrate-horizontal direction, wherein the plurality of display regions and the touch sensing region are not overlapped;
a plurality of light-emitting devices disposed over the substrate in the plurality of display regions, each of the plurality of light-emitting devices comprising:
an anode and a cathode having a polarity opposite to a polarity of the anode;
an organic light-emitting layer;
a first carrier layer, coupled to the organic light-emitting layer and the anode; and
a second carrier layer, coupled to the organic light-emitting layer and the cathode,
wherein at least one of lateral sidewalls of the first carrier layer and the second carrier layer is in contact with the organic light-emitting layer from a cross section; and
at least one touch sensor disposed over the substrate in the touch sensing region, wherein the touch sensing region surrounds each light-emitting device, and bottom surfaces of the touch sensor, the anode and the cathode are coplanar.

12. The display panel of claim **11**, wherein
the anode is disposed at one side of the organic light-emitting layer,
the cathode is disposed at the same side of the organic light-emitting layer as the anode, and
the anode is spaced apart from the cathode.

13. The display panel of claim **11**, wherein the anode, the cathode and the touch sensor comprise a same material.

14. The display panel of claim **13**, wherein the anode, the cathode and the touch sensor are made of a same conductive layer.

15. The display panel of claim **11**, wherein the first carrier layer is spaced apart from the second carrier layer.

16. The display panel of claim **11**, wherein the first carrier layer and the second carrier layer are disposed at the same side of the organic light-emitting layer as the anode and the cathode.

17. The display panel of claim **11**, wherein the first carrier layer comprises a hole-transporting layer (HTL) and a hole-injecting layer (HIL), and the second carrier layer comprises an electron-transporting layer (ETL) and an electron-injecting layer (EIL).

18. The display panel of claim **11**, wherein the touch sensing region surrounds each display region.

19. The display panel of claim **11**, further comprising a dielectric structure disposed over the substrate and the touch sensor, at least a portion of the dielectric structure is disposed between the touch sensor and each light-emitting device along the substrate-horizontal direction, and the touch sensor is electrically isolated from the plurality of light-emitting devices by the portion of the dielectric structure.

20. The display panel of claim **11**, further comprising an array layer disposed over the substrate.

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